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Sustainability Innovation Systems (SIS): IT Investments and Stages of Sustainability Maturity

Full paper

Thomas Abraham
Kean University
tabraham@kean.edu

Kannan Mohan
Baruch College
kannan.mohan@baruch.cuny.edu

Abstract

We synthesize a new longitudinal framework for investing in IT assets to support sustainability and to prescribe specific investments for each stage of sustainability. This framework provides an IT investment plan for organizations that supports the five stages of sustainability and will positively moderate the relationship between an organization's ability to traverse the stages of sustainability and organizational innovation. We propose that there is an innovation payoff at each stage and support that proposition with exemplars from the literature. To highlight their key role in supporting sustainability driven innovation, we choose to call these IT investments Sustainability Innovation Systems (SIS).

Keywords (Required)

sustainability, IT investments, innovation, green IT.

Introduction

The Brundtland Commission's definition of sustainability (Brundtland 1987) - "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" – is inclusive of both environmental and social sustainability. Debate of the impact of inequality highlights the importance of social sustainability (Picketty 2014). The term triple bottom line (Elkington 1998) – often used to consider social and ecological factors in addition to economic ones to better measure progress – is often raised as central to the mission of responsible organizations. Prior literature on Information Systems has referred to the domain that focuses on the relationship between Information Technology and sustainability as Green IT or Green IS with somewhat different focus areas (Boudreau et al. 2008). Firms typically follow a staged path to sustainability maturity (Lubin et al. 2010; Nidumolu et al. 2009), initially focusing on eco-efficiency or reducing costs and risks as a way to address sustainability. Firms eventually focus on eco-effectiveness and develop new business models and platforms. We are now in the second wave of Sustainable IT (Harmon et al. 2011) where some organizations recognize that sustainability fosters innovation and IT must support the sustainable strategy of the business. While prior research has identified five stages in the organizational path to sustainability, each producing innovations (Nidumolu et al. 2009), the nature of IT investments necessary to support each of the stages has been largely unexplored. This leads us to our research question: "What kind of IT investments support organizations at different stages of sustainability and thereby drive innovation?" We develop a conceptual framework that addresses this question by proposing different types of IT investments for various stages of sustainability and highlighting the potential for innovation payoffs for all stages of sustainability. We prescribe specific investments in IT asset classes for each stage of sustainability and we refer to these investments as Sustainability Innovation Systems (SIS).

Literature Review

Information Technology (IT) contributes substantially to the problems of climate change. It is estimated that IT uses three percent of global energy use and contributes three percent of the greenhouse gases (Ruth 2009). IT though, also offers powerful solutions to the sustainability crisis and we focus here on these solutions.

Sustainability as the Key Driver for Innovation

There is a growing body of research that highlights the benefits of a sustainability mission for organizations. In a recent MIT Sloan Management Review and Boston Consulting Group report (Kiron et al. 2013), a survey of over a thousand global executives showed that nearly two thirds of respondents consider sustainability issues significant. Sarkis and Vasquez-Brust (2010) bring together articles on sustainability, innovation and collaboration. Esty and Winston (2009) provide examples of turning "green to gold". Porter and Kramer (2011) make a strong case that capitalism is in crisis and call for expanding the mission of business to creating shared value with society. In doing so they show how "whole new avenues for innovation open up" (p. 7).

Eccles et al. (2014) demonstrate that over an 18 year period from 1993 to 2010, firms with a high commitment to sustainability outperformed "low sustainability" firms both in stock performance and profitability. Eccles & Serafeim (2013) also showed that a high commitment involved a strategic focus on the most material environmental, social and governance (ESG) issues and the ability to produce major innovations in products, processes and business models that address these issues. Companies that can then innovate products, processes and business models that prioritize addressing the most material ESG issues can reap great financial success. Using integrated ESG and financial reports is one way to do this. In addition, social media such as the Natura Connect allow for collaborative exchanges with stakeholders.

Nidumolu et al. (2009) demonstrate that a sustainability objective drives innovation. In other words, firms will find that adopting sustainability as a core value or mission actually promotes and drives innovation that will provide them with a competitive advantage. They identify five stages in the organizational path to sustainability, each producing innovations. In Stage 1, companies "view compliance as an opportunity" and comply with the most stringent regulations across all regions. In Stage 2, companies make "value chains sustainable" by working with suppliers and retailers to develop more sustainable practices and products. In Stage 3, companies recognize consumer segments which prefer sustainable products and services and begin to design or redesign products for them.

In Stage 4, firms "develop new business models" by rethinking both process and product. In Stage 5, companies must "create next-practice platforms" by questioning the assumptions underlying their current business practices. To support each stage of sustainability, IT departments would then need to invest in the appropriate IT assets. We call these assets and roles Sustainability innovation systems (SIS) and prescribe specific IT investments for each stage of sustainability**.**

Categories of IT roles and investments

The role of IT in an organization has been categorized as automate, informate and transform (Schein 1992; Zuboff 1988). IT resources or asset classes have also been categorized as infrastructural, transactional, informational and strategic (Weill 1992; Weill et al. 1998). Infrastructural assets include both technical and human assets such as servers, networks, user devices, shared databases, and help desk. Transactional assets include process automation such as order fulfillment. Informational assets provide information to manage and communicate internally and externally and include business intelligence and Sarbanes-Oxley reporting. Strategic assets support entering new markets or developing new products and processes such as web services or smart devices.

Further, Aral and Weill (Aral et al. 2007) demonstrate that investments in different asset classes are associated with different measures of firm performance. Transactional assets typically reduce costs while informational assets increase profits. Infrastructural assets increase costs in the short run but increase market valuation with the expectation of long-term benefits such as integration. Finally, strategic assets were found to increase innovation measured as increased revenue from modified products. Such IT asset classes can be mapped to different types of sustainability initiatives. For example, Dao et al.'s (Dao et al. 2011) integrated sustainability framework presents a 2 x 2 matrix based on two dimensions – time (today/tomorrow) and firm boundary (internal/external) . The framework proposes that an internal-today focus entails optimizing the IT infrastructure to reduce energy usage while automation, such as digital documents and e-filing, reduces waste and frees up employees to focus on process improvement. An external-today focus increases the need for IT infrastructure integration and for informate resources. Demands from external stakeholders for sustainability information make it necessary to develop informate resources such as Global Reporting Initiative (GRI) capabilities. However, this capability requires information exchange across the supply chain and the need for investments in IT infrastructure integration. An internal-tomorrow focus increases the need for a flexible IT infrastructure, that can handle future needs and for transform resources that can innovate new products and processes. As companies attempt to create radical clean technologies and processes such as reverse logistics, they will need to invest in transformative IT resources that can support the new products and processes. In order to support changing products and processes, the IT infrastructure will need to be flexible. An external-tomorrow focus increases the need to create new markets in previously under-served communities and to develop sustainable products and services for them. This calls for IT informate resources to support collaboration with external stakeholders.

We adopt Osch and Avital's (2010) sustainable innovation lens to extend the concepts of Green IT and Green IS. They expand the focus from exclusively environmental concerns to the triple bottom line of people, planet and profits. They also move away from a mindset of reducing the impact of IT (green IT) and the firm (green IS), to a more innovative and proactive approach to solving social and environmental problems. They call this approach Sustainable Innovation. We expand their term to Sustainability Innovation Systems (SIS) to establish the connection between information systems, sustainability, and innovation.

A framework for Sustainability Innovation Systems (SIS)

Drawing on and expanding earlier frameworks, we synthesize a longitudinal framework (see Table 1) that proposes the potential for innovation payoffs for all stages of sustainability with the right IT investments. We prescribe specific investments in IT asset classes for each stage of sustainability and we refer to these investments as sustainability innovation systems (SIS).

Prescription 1: Investing in suitable IT assets and roles to support each stage of sustainability will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Stage 1 IT investments

In Stage 1, companies "view compliance as an opportunity" and comply with the most stringent regulations across all regions (Nidumolu et al. 2009). This creates economies of scale and also first mover advantages. HP is cited as an example since HP complied with European regulations such as WEEE and RoHS and applied those standards to their products globally. In addition, they were prepared for these regulations and developed alternatives to toxic lead solders even before the regulations went into effect. They also formed an alliance with Sony, Electrolux and Braun and created the European Recycling Platform in advance of WEEE, which has saved them millions in recycling fees.

Stages	IT Investment Focus	Innovations
1. Beyond compliance	Infrastructure Optimization and Automate assets Ex. DCIM, self-check-out registers	Business continuity; Lean systems and continuous improvement; New services like the European Recycling Platform
2. Sustainable value chains	Infrastructure Integration and supply chain facing Informate assets Ex. ESM, VPNs, Reverse logistics IS, LMS	Telecommuting, Lean supply chains, blended learning, Patagonia's transparent supply chain, Fresh Direct's green leaf deliveries; New products/services like selling electricity, insourcing, refurbished products
3. Sustainable products/services	Market facing Informate assets Ex. Social media IS, Collaboration IS, Crowdsourcing, Big data	Sustainable choices like the Prius and Clorox Green Works, energy optimization services like IBM's Green Horizon. Social innovations like microcredit and fair trade and employee online education like Starbucks
4. New business models	Business model Transform assets Ex. MOOCs, Bio-mimicry databases	Progressive's Snapshot device; Free higher education; Flipped classrooms; Bio-mimicking products
5. Next practice platforms	Infrastructure flexibility And platform Transform assets Ex. Exchanges, SaaS, FMS, mobile platforms, cloud computing	Spaza shops; Smart Grid; Sharing economy ; Crowd funding ; Internet of Things

TABLE 1: A staged approach to IT investments and sustainable innovation

In Stage 1, we expect the focus to be on current internal processes and for IT investments to be made in infrastructure optimization and automate assets. These investments however, will produce not just cost savings and more sustainable operations but also innovation that could position the organization ahead of its competitors in meeting future regulatory compliance. For instance, while reducing energy usage as a goal might lead to compliance, considering innovations such as total preventative maintenance that improves business continuity will help organizations go beyond compliance (Abraham 2013). The extent to which a firm at stage 1 drives innovation is shaped here by the appropriate IT investment in solutions such as Data Center Infrastructure Management (DCIM) products. Similarly, automation of routine tasks (self-check-out counters) allows workers to focus on such lean systems principles as quality at the source (jidoka) and continuous improvement, which result in innovation.

Further, the initial investments in infrastructure optimization could lead to future disruptive innovation as well. For instance, an initial investment in virtualization and blade servers (automate assets) could potentially lead to a move to cloud computing (transform assets). This is consistent with what has been

highlighted by prior work in this area that has focused on classifying disruptive innovations that pertain to sustainability initiatives that span intra and inter-organizational boundaries (Mohan et al. 2011).

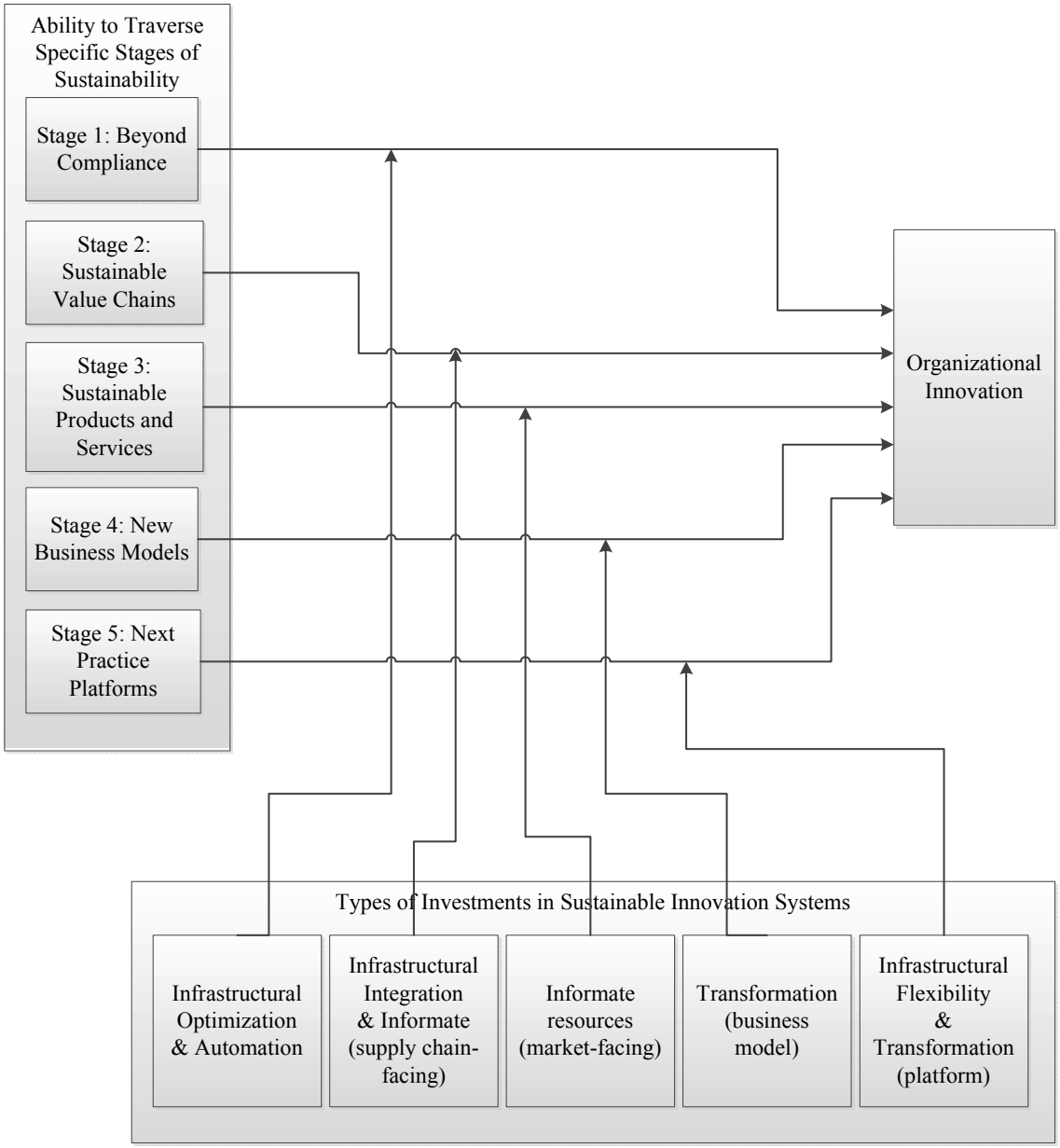

Figure 1: Prescribed investments in IT assets support sustainability, which drives innovation

Prescription 2: At stage 1 (beyond compliance), investing in infrastructural optimization and automation will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Stage 2 IT investments

In Stage 2, companies make "value chains sustainable" by working with suppliers and retailers to develop more sustainable practices and products (Nidumolu et al. 2009). This includes operations, the supply chain and returns. Wal-Mart for instance has aggressively pursued a sustainability strategy and has required suppliers in China to increase the energy efficiency of products and reduce packaging. Cisco created a profit center out of the recycling group and now reuses 45% of the returned equipment.

In Stage 2, we argue that the focus moves to current external processes and for IT investments to be made in integration of infrastructure assets such as building integrated platforms. These investments will support making value chains sustainable. Virtual Private Networks (VPNs) allow employees to telecommute and Learning Management Systems (LMS) promote online or blended classes, both sustainable social innovations. We also expect investments in supply chain-facing informate assets to increase. For instance, an energy and sustainability management (ESM) system, will allow firms to collect and share sustainability data across the supply chain, which is necessary for sustainability accounting such as the Global Reporting Initiative. The payoff from a sustainability mission is more than reputational – it is innovational. Forced to address regulations on waste disposal, a sugar refinery in Gujarat, India (Abraham 2013) ended up identifying a highly profitable business opportunity from a waste product. Sugar refining produces bagasse, the fiber left over from sugarcane, which can be used as a biofuel for generating electricity. The excess electricity can then be sold back to a utility at a higher margin than the sugar itself! The refinery adopted an ESM product which allowed the refinery to not only improve the water usage efficiency and proper waste disposal but also helped it to manage the sale of electricity to the utility. Information systems which trace the source of inputs to the new product or service development process can be used to conduct what-if analyses on the inputs to find innovative and sustainable alternatives. Systems that support reverse logistics can not only reduce waste but create innovations such as insourcing and refurbished products. The extent to which a firm at stage 2 drives innovation is shaped here by the appropriate IT investment in solutions such as energy and sustainability management (ESM) products.

Consistent with Zuboff's (Zuboff 1988) prediction, we argue that automate and infrastructure assets such as an online store created in stage 1, provide new opportunities for informate IT roles in stage 2. For example, the grocery delivery company, Fresh Direct, allows customers to select delivery times shared with neighbors by highlighting those times with a green leaf. Patagonia allows customers to trace the supply chain of its products and view the working conditions of employees of its partners.

Prescription 3: At stage 2 (sustainable value chains), investments in infrastructural integration and informate resources (that are supply chain facing) will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Stage 3 IT investments

In stage 3 of sustainability - titled "designing sustainable products and services" - companies recognize consumer segments which prefer sustainable products and services and begin to design or redesign products for them (Nidumolu et al. 2009). Examples of this approach include the Clorox Green Works line of cleaning products and P&G's Tide Coldwater (Nidumolu et al. 2009).

In Stage 3, we argue that a focus on moving to future products and for IT investments in market-facing informate assets will facilitate organizational innovation. Using social media systems to collaborate with various stakeholders such as suppliers and social and environmental groups and NGOs, companies can innovate around offering sustainable choices to customers. Several companies are working with environmental groups such as the Natural Resources Defense Council and certification organizations such as the Rainforest Alliance, to create and verify sustainable products and services. These globally dispersed and culturally distinct entities would find collaboration very difficult without the support of IT informate assets. Brazilian cosmetics giant Natura has created a social media site called Natura Connect to allow for collaborative exchanges with stakeholders. Cooperation among companies, governments and NGOs has led to such social innovations as microcredit (disrupting banking and payday lending), one laptop per child and online education (disrupting education models). The recent Starbucks announcement of free online education for all its employees through a cooperative agreement with Arizona State University is another example of informate assets strengthening the link between sustainability and social innovation. Organizations also need to allocate resources to monitor activity in

social media platforms to understand and respond to pressures from various stakeholders – consider for example the use of social media by activists that applied pressure on Coca Cola to open its facilities in India and other countries to third party audits. Timely monitoring of reactions in social media and establishing a proactive social media policy will enable considering stakeholder input in shaping organizational priorities, policies and products. The extent to which the ability of the firm to traverse stage 3 drives innovation is shaped here by the appropriate IT investment in market-facing informate solutions such as social media sites, data analytics and crowdsourcing .

Firms can use market-facing informate assets such as data analytics (Big Data) to identify customers for sustainable products and services. Political parties can use micro-targeting to identify voter interests and can frame sustainable issues in ways that can appeal to those voters. Green Button, an energy industry response to a White House initiative, allows consumers to view their energy usage, conduct energy audits and make changes. It also allows providers to customize energy savings tips to customers and third party companies to build tools for energy management. Companies like Retroficiency and WeatherBug use Green Button data and other sources of Big Data to conduct energy audits and identify savings. IBM has a "Green Horizon" project in partnership with the Chinese government to use data analytics to conduct air quality management, renewable energy forecasting and energy optimization.

Platforms to enable crowdsourcing (Majchrzak et al. 2013) constitute market-facing informate assets that firms can use to innovate for sustainability. In 2011, GE created the Ecomagination Challenge to generate ideas for smart grid technologies. One of the forums at IBM's InnovationJam 2008 was "The Planet and its People". In 2014, various organizations, from the AMA to Intel to the University of California, sponsored an Innovation HealthJam focused on new ideas for healthcare. Unilever, usually cited as the most admired sustainability focused company, held an online moderated dialog in 2013 called the Unilever Sustainable Living Lab. Experts and practitioners from business, governments, NGOs and academia were invited to share ideas and best practices in two virtual solution rooms. One room was for product innovations and the other for policy innovations. The ideas generated feed back into the work of sustainability steering teams at the company.

Prescription 4: At stage 3 (sustainable products and services), investments in informate resources (that are market facing) will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Stage 4 IT investments

In Stage 4, firms "develop new business models" by rethinking both process and product (Nidumolu et al. 2009). FedEx used the Kinko shops to create a new model for document delivery that was more sustainable and improved delivery time and the quality of the document. Calera used bio-mimicry to develop a new process of making cement out of seawater and carbon dioxide emissions from other factories. An MIT SMR report on sustainability (Kiron et al. 2013) found that a majority of companies that changed multiple business model elements report profits from their sustainability efforts.

In Stage 4, we expect the focus to move to internal capabilities for the future and for investments in business model transform assets to increase. In higher education, investments in the technologies of online learning such as learning management systems (LMS) initially led to innovations such as blended classrooms. Today, massive open online courses (MOOCs) hold the potential to disrupt the existing university business model. Now The Biomimicry Institute offers a free asset called Ask Nature (www.AskNature.org), described as a bio-mimicry design portal. Using this business model transform IT asset, Qualcomm has designed a display based on the science behind the brilliant colors of a butterfly's wings. Teijin Fibers Limited has eliminated the use of dyes by copying the layering design of the Morpho butterfly. This reduces energy consumption and waste. The extent to which the firm at stage 4 drives innovation is shaped here by the appropriate IT investment in transforms assets such as MOOCs and Ask Nature.

These IT assets could also reduce negative externalities. Externalities are costs that the individual or firm do not bear and instead pass them on to the community thus setting up the "tragedy of the commons" scenario where maximizing individual self-interest degrades the commons. Firms are now exploring ways to incentivize good behavior that reduces externalities. One example is the Snapshot program from Progressive Insurance. Drivers attach a device called the Snapshot to their car and it tracks their driving behavior. Drivers who reduce the miles driven as well as other driving behavior that increase accident

risks receive a discount on their insurance premiums. Not only does this develop IT as a facilitator of sustainability, it also creates a new business model for auto insurance where drivers are tracked at all times and insurance products are tailored to their driving habits.

Prescription 5: At stage 4 (new business models), investments in transform roles will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Stage 5 IT investments

Stage 5 of sustainability - "creating next practice platforms" – entails companies questioning the assumptions underlying their current business practices. Asking questions about scarce resources such as water, oil and land can lead to innovations that reduce their use. This is a form of Blue Ocean strategy (Kim and Mauborgne 2005) which rejects the current structure of the industry to create new value innovation propositions. Cross-industry collaboration will also be necessary. For instance, the smart grid promises to reduce the energy use of cities, companies and households by bringing together the internet and energy technologies. Technology vendors like IBM and HP are working alongside utilities to create this platform.

In stage 5, we expect the focus to be future-oriented and both internal and external and for IT investments in infrastructure flexibility and platform transform assets. A combination of automate (web-based transactional systems), informate (social media and trust-based systems) and infrastructure (software as a service, mobile devices, mobile apps) assets are helping to create platform transform assets and disrupt several industries. The extent to which the firm at stage 5 drives innovation is shaped here by the appropriate IT investment in infrastructural flexibility and platform transform assets such as CleanWeb (cleanweb.co) products. The sharing economy depends on transform assets to disrupt the travel industry (AirBnB), the automobile, taxi and auto rental industry (Zipcar, Uber, Lyft and BlaBlaCar), and even the clothing industry (ThredUP). New exchanges like Mosaic and Kickstarter and Kiva are providing crowd funding for renewable energy and social projects. Mobile apps that allow "spaza" shops in South Africa to re-order supplies can potentially disrupt the existing model since new co-operatives of many spaza shops collectively shop for supplies, driving down prices. The Internet of Things promises to reduce waste, loss and cost by automatically tracking "things", such as light bulbs, appliances and devices. Already many companies like SmartThings offer a platform for objects in the home to communicate with each other where a user needs only a smartphone and a starter kit.

Prescription 6: At stage 5 (next practice platforms), investments in infrastructural flexibility and transform assets will strengthen the relationship between an organization's sustainability strategy and organizational innovation.

Conclusions

We synthesize a new longitudinal framework for investing in IT assets to support sustainability and to prescribe specific investments for each stage of sustainability. This framework provides an IT investment plan for organizations that supports the five stages of sustainability and thus drives innovation. We propose that there is an innovation payoff at each stage and support that proposition with exemplars from the literature. To highlight their key role in supporting sustainability driven innovation, we choose to call these IT investments Sustainability Innovation Systems (SIS).

What are the implications of the stages and prescriptions that we have described above for organizations and managers? We identify three recommendations (see Figure 1) that will help organizations connect IT, sustainability, and innovation.

1. IT strategy must align with the business sustainability strategy. IT managers must consider that sustainability is now recognized as a key driver of innovation and that successful companies are developing a sustainability strategy. In aligning the IT function with the business strategy, investments in Sustainability innovation systems must be made.

2. Calibrate the portfolio of IT projects with sustainability in mind: A portfolio-based approach to investing in IT projects has been well recognized. We argue that when organizations develop such a portfolio, they need to identify the stage of sustainability they are currently at and calibrate the investments necessary in various IT asset classes accordingly. Not only will this help organizations develop their resources focusing on sustainability, it will also foster a culture of innovation.

3. Facilitate IT assets to play different roles: Our framework highlights that in certain instances the same IT asset class can play considerably different roles in enabling the organization to traverse the different stages of sustainability. For example, while informate resources can help organizations streamline their value chain with a focus on sustainability, informate resources can also help in market-facing activities (monitoring customer sentiment in social media platforms, crowdsourcing, etc.) Similarly, Transformational IT resources can help organizations transform their business model (stage 4) or facilitate platform transformation leading to changing industry structures (stage 5). We argue that organizations need to recognize such nuanced differences in how IT assets can be used in different stages.

An important next step in examining the role of IT assets in enabling sustainability and thereby fostering innovation is to examine the complementarity between various IT assets and how such complementarity might lead to previously underexplored outcomes for sustainability.

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